

1                                    TITLE

2    Exhaust gas after\_treatment system, especially for a diesel  
3                                    engine  
4

5  
6                                    CROSS REFERENCE APPLICATIONS

7    This application is a national stage application  
8    claiming priority from PCT application no. PCT/EP03/109171  
9    filed on October 2, 2003 and claiming priority from German  
10   application 102 50 050.96 filed on October 25, 2002.  
11

12                                    FIELD OF INVENTION

13   The invention relates to an exhaust gas after\_treatment  
14   system, especially for a diesel engine, having the features  
15   of the preamble of claim 1.  
16

17                                    BACKGROUND OF THE INVENTION

18   German laid-open specification DE\_-100\_-42\_-542\_-A1 has  
19   described an exhaust gas after\_treatment system having an  
20   exhaust gas particulate filter and an SCR catalytic  
21   converter. The exhaust gas particulate filter and the SCR  
22   catalytic converter are arranged in the housing of the  
23   exhaust gas after\_treatment system and form a structural  
24   unit therewith. Urea is used as\_a reducing agent for the  
25   selective catalytic reduction of nitrogen oxides and is

1 | injected into a special tube element, ~~—.~~ which ~~The special~~  
2 | tube element is arranged in the housing parallel to the  
3 | exhaust gas particulate filter and has filtered exhaust gas  
4 | flowing through it, with the urea then being fed to the SCR  
5 | catalytic converter. In the housing there is a plurality of  
6 | chambers which are separated from one another by partitions  
7 | and act as reflection chambers and/or absorption chambers,  
8 | thereby producing a muffling action.

9 |  
10 |       It is an object of the invention to provide an exhaust  
11 | gas after\_treatment system which can achieve comprehensive  
12 | exhaust gas purification, which is of structurally simple  
13 | and compact configuration and can be used for optimum sound  
14 | muffling.

15 |  
16 |       According to the invention, this object is achieved by  
17 | an exhaust gas after\_treatment system having the features of  
18 | claim 1.

#### 19 |                   SUMMARY OF THE INVENTION

20 |  
21 |       According to the invention, the exhaust gas particulate  
22 | filter is formed as a porous cylindrical filter body having  
23 | a substantially radial exhaust gas inflow direction into the  
24 | filter body, a filter inner region for filtered exhaust gas,  
25 | and an axial exhaust gas outflow direction out of the filter

1 inner region, and there is provision for reducing agent to  
2 be added into the filter inner region by means of the  
3 apparatus for adding reducing agent.

4  
5 The filter body is designed as a cylindrical hollow  
6 body with a porous cylinder wall and is preferably  
7 configured in such a way that filtered exhaust gas can flow  
8 out of the filter inner region in the axial direction on one  
9 side. The filter inner region in this context is to be  
10 understood as meaning the volume region which can be filled  
11 with filtered exhaust gas upstream of the outflow-side  
12 filter body end. The wall material of the filter body can  
13 act as a depth filter or as a surface filter and may be  
14 formed from any desired porous material which has a  
15 filtering action and is able to withstand exhaust gases,  
16 ~~such as~~ for example metal foam or ceramic foam. Moreover, it  
17 may additionally be provided with a catalytic coating on the  
18 outer side, the inner side or in the porous interior of the  
19 material.

20  
21 A suitable nitrogen oxide reduction catalytic converter  
22 is any catalytic converter which is able to catalyze the  
23 reduction of nitrogen oxides by a suitable reducing agent.  
24 The reducing agent used may be any reagent which has a  
25 nitrogen oxide reduction activity. The nitrogen oxide

1 reduction catalytic converter is preferably designed as a  
2 standard SCR catalytic converter based on vanadium  
3 pentoxide, and therefore the reducing agent is ammonia or a  
4 liquid from which ammonia can be released. It is preferable  
5 for the reducing agent used to be aqueous urea solution.  
6 Accordingly, the apparatus— for adding reducing agent is  
7 preferably designed as an injection nozzle.

8  
9 The particulate filter and the downstream nitrogen  
10 oxide reduction catalytic converter may be arranged in  
11 separate housings or in a common housing.

12  
13 The addition of reducing agent into the inner region of  
14 the filter body results in a space-saving design solution  
15 with short gas paths. This prevents cooling of the exhaust  
16 gas before the reducing agent is added, resulting in  
17 favorable thermal conditions for preparation of the reducing  
18 agent, for example for release of the ammonia or for  
19 evaporation. Moreover, the addition of reducing agent into  
20 the filter inner region achieves a good uniform distribution  
21 and homogenization of the reducing agent in the exhaust gas.

22  
23 In one configuration of the invention, the filter body  
24 is formed by porous filter plate rings which are combined in  
25 pairs. It is preferable for the filter body to be formed

1 from flat, annular sintered-metal filter plates which are  
2 fixedly joined to one another, for example by a weld seam,  
3 alternately and in pairs along their outer circumference and  
4 along their inner ring circumference. It is preferable for  
5 the filter body to have a sealed end plate at one end, while  
6 an annular, gastight end plate is arranged at the other end;  
7 the filtered exhaust gas can flow out of the opening in the  
8 annular end plate in the axial direction. The filter plate  
9 rings may be of any desired shape, but it is preferable for  
10 them to be approximately round with a central hole in the  
11 middle. This produces a cylindrical filter body with a shape  
12 similar to an accordion with contours that are approximately  
13 in zigzag form when seen in longitudinal section. This is  
14 distinguished by a large filter surface area and a low  
15 pressure loss, as well as a high muffling action. This makes  
16 it possible to substantially dispense with any further  
17 structural muffling measures in the exhaust gas  
18 aftertreatment system.

19  
20 In a further configuration of the invention, the  
21 nitrogen oxide reduction catalytic converter and the  
22 particulate filter are arranged in a common housing. This  
23 avoids the need for multiple exhaust gas connections and  
24 produces a compact structure of the exhaust gas  
25 aftertreatment system. In particular in the case of an

1 exhaust gas particulate filter constructed from  
2 sintered-metal filter rings, an exhaust gas muffler with an  
3 exhaust gas purification function is realized by this  
4 structure on account of its muffling action.

5  
6 In a further configuration of the invention, there are  
7 flow guiding means for passing on filtered exhaust gas to  
8 the nitrogen oxide reduction catalytic converter, which flow  
9 guiding means comprise a collection manifold led out of the  
10 filter inner region of the filter body. If the filter body  
11 is constructed from sintered-metal filter rings, the  
12 collection manifold, in addition to collecting and passing  
13 on exhaust gas, also serves to increase mechanical  
14 stability. The individual filter plate rings can be  
15 supported on the collection manifold. In the filter inner  
16 region, the collection manifold preferably has a perforated  
17 wall for the exhaust gas entry. If the nitrogen oxide  
18 reduction catalytic converter and the particulate filter are  
19 arranged in a common housing, it is furthermore possible for  
20 one or more partition walls to be arranged suitably in the  
21 housing, by which partitions the housing is divided into  
22 chambers. In this case, the partition or partitions likewise  
23 serve as flow guiding means for passing on filtered exhaust  
24 gas to the nitrogen oxide reduction catalytic converter or  
25 serve to route the exhaust gas flow in some other way in the

1 interior of the housing and at the same time prevent  
2 back-mixing.

3  
4 In a further configuration of the invention, a  
5 catalytic converter element is arranged in the collection  
6 manifold. A catalytic converter element of this type, as  
7 seen in the direction of flow of the exhaust gas, may be  
8 arranged both in the filter inner region preferably just  
9 downstream of the location where the reducing agent is  
10 added, or further downstream. In the case of the urea being  
11 used as the reducing agent, it is preferably designed as a  
12 hydrolysis catalytic converter which promotes the release of  
13 ammonia. The arrangement of the catalytic converter element  
14 according to the invention produces a particularly compact  
15 and space-saving overall design.

16  
17 In a further configuration of the invention, the  
18 nitrogen oxide reduction catalytic converter is arranged  
19 axially parallel and adjacent to the collection manifold. In  
20 an arrangement of this type, the nitrogen oxide reduction  
21 catalytic converter may comprise one or more catalytic  
22 converter parts. If the nitrogen oxide reduction catalytic  
23 converter is of multi-part design, it is preferable for the  
24 individual catalytic converter parts to be arranged axially  
25 parallel around the collection manifold. This embodiment

1 allows the volume of the nitrogen oxide reduction catalytic  
2 converter to be increased in a space-saving way.

3  
4 In a further configuration of the invention, an  
5 oxidation catalytic converter is connected upstream of the  
6 exhaust gas particulate filter, as seen in the direction of  
7 flow of the exhaust gas. This can be realized by a separate  
8 catalytic converter element in a separate housing or in the  
9 housing in which the exhaust gas particulate filter is  
10 arranged. The oxidation catalytic converter is used, for  
11 example, to oxidize hydrocarbons or to oxidize nitrogen  
12 monoxide to form nitrogen dioxide. The latter improves the  
13 regeneration behavior of the particulate filter.

14  
15 In a further configuration of the invention, the  
16 exhaust gas particulate filter and the oxidation catalytic  
17 converter are arranged in a common housing. This arrangement  
18 produces a particularly compact structural unit.

19  
20 In a further configuration of the invention, an exhaust  
21 gas recirculation line which is led out of the filter inner  
22 region for branching off a part-stream of filtered exhaust  
23 gas upstream of the addition of reducing agent and for  
24 recirculating this part-stream of filtered exhaust gas to  
25 the diesel engine is provided. The result of this measure is

1 that filtered exhaust gas that is free of reducing agent in  
2 the exhaust gas recirculation line is fed to the diesel  
3 engine. This prevents condensation in the components which  
4 come into contact with the recirculated exhaust gas.

5  
6 ~~The text which follows provides a more detailed explanation~~  
7 ~~of the invention on the basis of drawings and associated~~  
8 ~~examples. In the drawings:~~

9 Other aspects of this invention will appear from the  
10 following description and appended claims, reference being  
11 made to the accompanying drawings forming a part of this  
12 specification wherein like reference characters designate  
13 corresponding parts in the several views.

#### 14 15 BRIEF DESCRIPTION OF THE DRAWINGS

16 Fig. 1—~~shows~~is a diagrammatic sectional illustration of an  
17 embodiment of the exhaust gas purification system  
18 according to the invention.,~~and~~

19  
20 Fig. 2—~~shows~~is a diagrammatic sectional illustration of a  
21 further embodiment of the exhaust gas purification  
22 system according to the invention.

23  
24 Before explaining the disclosed embodiment of the  
25 present invention in detail, it is to be understood that the

1 invention is not limited in its application to the details  
2 of the particular arrangement shown, since the invention is  
3 capable of other embodiments. Also, the terminology used  
4 herein is for the purpose of description and not of  
5 limitation.

#### 6 7 DETAILED DESCRIPTION OF THE DRAWINGS

8 Fig. 1 diagrammatically depicts a longitudinal section  
9 through an embodiment of the exhaust gas purification system  
10 according to the invention. In the present case, this system  
11 comprises a particulate filter 3 and an SCR catalytic  
12 converter comprising two honeycomb monoliths 7, 8, which are  
13 arranged in a common housing 2 having an entry tube 1 and an  
14 outflow tube 9. A collection manifold 6 and partitions 18,  
15 19, 20, 21 are provided in the housing 2 for the purpose of  
16 routing the exhaust gas. The way in which the exhaust gas  
17 purification system functions is explained below with  
18 reference to the description of the exhaust gas flow path,  
19 which is diagrammatically indicated by arrows.

20  
21 Exhaust gas from a diesel engine (not shown) flows  
22 through the entry tube 1 into an inflow chamber 10 of the  
23 housing 2. The partition 18 separates the inflow chamber 10  
24 from a particulate filter chamber 11, in which the  
25 particulate filter 3 is arranged. Along its circumference,

1 the partition 18 is joined to the housing 2, but it has  
2 apertures in the form of holes, preferably arranged in a  
3 ring along its edge region. These apertures allow the  
4 exhaust gas which has flowed into the inflow chamber 10 to  
5 pass into the particulate filter chamber 11. The partition  
6 19 delimits the other end side of the particulate filter  
7 chamber 11 and prevents unfiltered exhaust gas from being  
8 transferred onward into the part of the housing located  
9 further downstream

10

11       The particulate filter 3 is constructed from individual  
12 filter rings, of which just one filter ring 4 is provided,  
13 as a representative example, with a reference numeral. The  
14 individual filter rings are designed as sintered-metal  
15 filter plates with a central hole and are fixedly joined to  
16 one another, for example by a weld seam, on alternate sides  
17 and in pairs along their outer circumference and along their  
18 inner ring circumference. This forms a filter body which is  
19 accordion-like in form with outer and inner filter pockets.  
20 The end-side filter rings of the filter body are joined in a  
21 gastight manner to the respective partitions 18, 19 all the  
22 way around. The exhaust gas which has entered the  
23 particulate filter chamber 11 therefore flows onward through  
24 the filter rings of the filter body into the filter inner  
25 region 26, with particulates contained in the exhaust gas

1 being filtered out in the process. The main direction of  
2 flow of the exhaust gas therefore runs radially from the  
3 outer region of the filter body into its inner region 26.

4  
5 In the filter inner region 26, the filtered exhaust gas  
6 is received by a collection manifold 6, which is designed  
7 with perforations on its lateral surface in the interior of  
8 the filter body. The collection manifold 6 preferably has  
9 the same cross section as the holes in the sintered-metal  
10 filter plates over the majority of its length; consequently,  
11 the sintered-metal filter plates are supported against the  
12 collection manifold 6 in the form of a ring all the way  
13 around it in the interior of the filter body, resulting in a  
14 high mechanical stability of the filter body.

15  
16 At encircling gastight connections, the collection  
17 manifold 6 is routed out of the particulate filter chamber  
18 11, on one side through partition 18 and on the other side  
19 through partitions 19, 20, 21, into the inflow chamber 10  
20 and into a first diversion chamber 14, respectively. In the  
21 region of the inflow chamber 10, an apparatus for adding  
22 reducing agent is connected in a gastight manner to the  
23 collection manifold 6. This apparatus is only  
24 diagrammatically indicated in Fig. 1, as a feed line 17 for\_  
25 a urea- and water solution, which is routed into the

1 collection manifold 6, which narrows at the corresponding  
2 | end. Urea=and water solution as reducing agent can be  
3 injected into the filter inner region 26 through the feed  
4 line 17, in a manner which is targeted and in accordance  
5 with demand but is not indicated in more detail here. It is  
6 | preferable for the injection of the urea=and water solution  
7 to be assisted by compressed air. In the end region of the  
8 feed line 17, the collection manifold 6 widens out in the  
9 direction of flow, resulting in a good uniform distribution  
10 of the reducing agent supplied in the filter inner region  
11 26. To further improve the distribution of reducing agent,  
12 for example by swirling it up, the collection manifold 6 may  
13 be provided, in the conically narrowing end region, with  
14 holes (not shown) which allow a small quantity of unfiltered  
15 exhaust gas from the inflow chamber 10 to enter the  
16 collection manifold 6. This results in further improved  
17 mixing of the reducing agent which is added with filtered  
18 | exhaust gas in the upstream region of the -collection  
19 manifold 6.

20 |  
21 | To prepare the reducing agent which has been added  
22 and/or to improve the release of ammonia from the urea which  
23 is added, it is possible for a suitable catalytic converter  
24 to be arranged in the collection manifold 6. This catalytic  
25 converter is in this case embodied by the catalytic

1 converter disks 15 and 16, which act as hydrolysis catalysts  
2 prompting the decomposition of urea and the release of  
3 ammonia. The hydrolysis catalyst may in principle be  
4 arranged at any desired location in the collection manifold  
5 6 downstream of the addition of urea, but it is preferable  
6 for a first catalytic converter part 15 to be arranged just  
7 downstream of the addition of the urea and for a second  
8 catalytic converter part 16 to be arranged in the end region  
9 of the collection manifold 6. The hydrolysis catalyst may in  
10 this case be designed such that it can be electrically  
11 heated completely or in parts, in order to further improve  
12 the decomposition of urea.

13  
14       The exhaust gas which has been mixed with the reducing  
15 agent is passed through the collection manifold 6 until it  
16 reaches a first diversion chamber 14, where it emerges from  
17 the end-side opening of the collection manifold 6. From  
18 there, it is fed to the nitrogen oxide reduction catalytic  
19 converter. The latter is in this case realized by two  
20 cylindrical SCR catalytic converter monoliths 7, 8, which  
21 are arranged axially parallel and adjacent to the collection  
22 manifold 6. However, it is, of course, also possible to  
23 arrange further catalytic converter parts fitted around the  
24 collection manifold 6. At their entry-side end, the SCR  
25 catalytic converters 7, 8 are passed through corresponding

1 openings in the partition 21, in a manner which is sealed  
2 all around. The partition 21, ~~which~~ is joined to the housing  
3 2 in a fixed and gastight manner along its circumference, and  
4 and therefore serves on the one hand both as a flow guiding  
5 means for the exhaust gas or exhaust gas/reducing agent  
6 ~~mixture and on the other hand~~ as a mechanical holder for the  
7 SCR catalytic converters 7, 8 and the collection manifold  
8 6. At their exit ~~=~~ side end, the SCR catalytic converters 7,  
9 8 are passed through corresponding openings in the partition  
10 20, although here the SCR catalytic converters 7, 8 do not  
11 necessarily have to be fitted in a gastight manner into the  
12 corresponding openings in the partition 20.

13  
14 The exhaust gas, which is purified by the removal of  
15 nitrogen oxides as it passes through the SCR catalytic  
16 converters 7, 8 emerges from the SCR catalytic converters 7,  
17 8 in a second diversion chamber, which is laterally  
18 delimited by the partitions 19, 20. Since the partition 20  
19 is of partially perforated design, whereas the partition 19  
20 forms a gastight closure with respect to the particulate  
21 filter chamber 11, the purified exhaust gas, after its  
22 direction of flow has changed, is passed onward through the  
23 perforated partition 20 into an outflow chamber 13.

24

1        In the outflow chamber 13, the exhaust gas is received  
2 by an outflow tube 9, which is routed from there through the  
3 partition 21 and the wall of the housing 2 and then out of  
4 the housing 2, so that the exhaust gas is passed out of the  
5 housing 2. The outflow tube 9 is preferably of perforated  
6 design at its entry-side end region and provided with a  
7 perforated end plate. This, like the perforations in the  
8 partitions 18 and 20, makes a contribution to muffling.

9  
10       The embodiment described therefore forms an exhaust gas  
11 after\_treatment system which is of structurally simple and  
12 compact configuration and can achieve comprehensive exhaust  
13 gas purification and, in addition, particularly effective  
14 muffling.

15  
16       The purifying action of the exhaust gas after\_treatment  
17 system according to the invention can be improved further by  
18 adding an additional catalytic function. This may consist,  
19 for example, in a catalytically active coating applied to  
20 the inflow\_-side or outflow\_-side surface of the filter  
21 rings. However, the catalytic function may also be realized  
22 by sintered\_-material filter rings in which the sintered  
23 material itself has a catalytic activity. Furthermore, it is  
24 possible for the catalytic function to be realized by plate  
25 elements with an oxidation/\_catalyzing action, for example,

1   secured to the filter body. Fig. 1 illustrates a single  
2   catalytic plate element 5 of annular design as a  
3   representative example of possibly a plurality of catalytic  
4   plate elements of this type;— ~~this~~ This catalytic plate  
5   element 5 extends in the radial direction into the outer  
6   region of the filter body. It is preferable for the filter  
7   body to be designed in accordance with what is described in  
8   German laid-open specification DE\_100\_35\_544\_A1 and  
9   provided with catalytically active plate elements.

10

11         Fig. 2 illustrates a further advantageous embodiment of  
12   the exhaust gas after\_treatment system according to the  
13   invention. In this case, the components of the arrangement  
14   shown in Fig. 2, where they correspond to the parts shown in  
15   Fig. 1, are denoted by the same reference numerals.

16

17         The exhaust gas after\_treatment system illustrated in  
18   Fig. 2 differs from the system illustrated in Fig.\_1  
19   substantially by virtue of having an oxidation catalytic  
20   converter, which in this case comprises two honeycomb  
21   monoliths 24, 25 and which is connected upstream of the  
22   particulate filter 3, as seen in the direction of flow of  
23   the exhaust gas. For this purpose, an intermediate chamber  
24   23 has been added to the housing 2 compared to the  
25   embodiment illustrated in Fig. 1. The intermediate chamber

1 23 separates the inflow chamber 10 from the particulate  
2 filter chamber 11 by means of the partition 22. The  
3 partition 22 has openings for the feed line 17 to pass  
4 through in a gastight manner and for receiving the catalytic  
5 converter bodies 24, 25 such that they are sealed all the  
6 way around, and moreover this partition 22 separates the  
7 inflow chamber 10 from the intermediate chamber 23 in a  
8 gastight manner. The exhaust gas which flows into the inflow  
9 chamber 10 of the housing 2 via the entry tube 1 is  
10 therefore passed into the intermediate chamber 23 via the  
11 catalytic converter bodies 24, 25 before it is fed into the  
12 particulate filter chamber 11. As a result, the exhaust gas  
13 undergoes an oxidation-catalyzing treatment before it is  
14 filtered, during which treatment the level of oxidizable  
15 constituents, such as hydrocarbons or carbon monoxide, in  
16 the exhaust gas is reduced. Furthermore, nitrogen monoxide  
17 contained in the exhaust gas can be oxidized to form  
18 nitrogen dioxide, thereby facilitating the burn-off of  
19 carbon particulates that have been deposited on the filter  
20 body. This embodiment makes it possible to dispense with the  
21 plate elements with an oxidation-catalyzing action secured  
22 to the filter body of the embodiment illustrated in Fig. 1.

23  
24 Further improvement to the emission of pollutants can  
25 be achieved by exhaust gas recirculation. For this purpose,

1 an exhaust gas recirculation line (not shown), which opens  
2 out into the filter inner region 26 upstream of the addition  
3 of reducing agent is routed out of the housing 2 and  
4 connected to the intake pipe system of the engine. In this  
5 way, filtered exhaust gas without any reducing agent can be  
6 recirculated to the engine. The exhaust gas recirculation  
7 described can of course be realized both in the embodiment  
8 shown in Fig. 1 and in the embodiment shown in Fig. 2.

9 |